

Claims

[0162] What is claimed is:

- 1 1. An animation deformation pipeline, comprising:
2 a head node, for converting a geometric representation of an object into a
3 data stream;
4 a plurality of deformation nodes, each for receiving the data stream from a
5 node, and for applying a deformation to the data stream;
6 a tail node, for converting the deformed data stream into a geometric rep-
7 resentation of a deformed object.
- 1 2. The animation deformation pipeline of claim 1, wherein at least a sub-
2 set of the deformation nodes apply deformations in response to manipulation of
3 a polygonal proxy model.
- 1 3. The animation deformation pipeline of claim 1, wherein each deforma-
2 tion node passes the data stream to a succeeding node.
- 1 4. The animation deformation pipeline of claim 1, wherein at least a sub-
2 set of the deformation nodes apply deformations using a sequential binding
3 mode.

1 5. The animation deformation pipeline of claim 4, wherein at least a sub-
2 set of the deformation nodes apply deformations to the result of a previous de-
3 formation node.

1 6. The animation deformation pipeline of claim 4, wherein each deforma-
2 tion node receives, within the data stream, a representation of a point, deforms
3 the point, and passes, to a succeeding node, a representation of the deformed
4 point.

1 7. The animation deformation pipeline of claim 1, wherein at least a sub-
2 set of the deformation nodes apply deformations using a parallel binding mode.

1 8. The animation deformation pipeline of claim 7, wherein at least a sub-
2 set of the deformation nodes apply deformations by combining influences of at
3 least two polygonal proxy models.

1 9. The animation deformation pipeline of claim 7, wherein each deforma-
2 tion node receives, within the data stream, a representation of a point, deforms
3 the point, and passes, to a succeeding node, a representation of the undeformed
4 point.

1 10. The animation deformation pipeline of claim 7, wherein each defor-
2 mation node receives, within the data stream, a representation of a point, de-

3 forms the point, and passes, to a succeeding node, a representation of the de-
4 formed point and a representation of the undeformed point.

1 11. The animation deformation pipeline of claim 1, wherein at least a sub-
2 set of the deformation nodes apply deformations using a blend binding mode.

1 12. The animation deformation pipeline of claim 11, wherein at least a
2 subset of the deformation nodes generate output that interpolates a current de-
3 formation with output of at least one other deformation node.

1 13. The animation deformation pipeline of claim 1, wherein at least a sub-
2 set of the deformation nodes apply deformations using a hierarchical binding
3 mode.

1 14. The animation deformation pipeline of claim 13, wherein at least a
2 subset of the deformation nodes apply deformations to a local origin point of an
3 input binding site.

1 15. The animation deformation pipeline of claim 1, wherein at least a sub-
2 set of the deformation nodes are associated with a user-specifiable weight pa-
3 rameter that controls the relative amount of deformation applied by the node.

1 16. The animation deformation pipeline of claim 15, wherein each defor-
2 mation node associated with a user-specifiable weight generates output repre-

3 sending a weighted combination of the input to the deformation node and the re-
4 sult of the deformation applied by the node.

1 17. The animation deformation pipeline of claim 15, wherein the weights
2 are normalized over the entire pipeline.

1 18. The animation deformation pipeline of claim 15, wherein the weights
2 are not normalized.

1 19. The animation deformation pipeline of claim 1, wherein each defor-
2 mation node applies its deformation by:
3 determining a binding site for at least one control vertex of the object;
4 transforming the binding site;
5 propagating the transformation of the binding site to the control vertex of
6 the object, to establish a new location for the control vertex; and
7 deforming the object according to the new location of the control vertex.

1 20. The animation deformation pipeline of claim 17, wherein the binding
2 sites are locations in a subdivision surface.

1 21. The animation deformation pipeline of claim 19, wherein the binding
2 sites are components of a polygonal proxy model, and wherein propagating the

3 transformation comprises deforming a subdivision surface, wherein the subdivi-
4 sion surface passes smooth deformations to the control vertices of the object.

1 22. The animation deformation pipeline of claim 1, wherein each defor-
2 mation node generates data stream output for another node, the data stream
3 output comprising a representation of the deformed object.

1 23. The animation deformation pipeline of claim 1, wherein the data
2 stream comprises a plurality of binding items to be deformed by deformation
3 nodes.

1 24. The animation deformation pipeline of claim 23, wherein the binding
2 items comprise tags specifying binding modes.

1 25. The animation deformation pipeline of claim 24, wherein each defor-
2 mation node has a binding mode, and wherein each deformation node applies
3 deformations on binding items having a tag specifying a matching binding
4 mode.

1 26. The animation deformation pipeline of claim 24, further comprising at
2 least one filter node for modifying tags.

1 27. The animation deformation pipeline of claim 24, wherein at least one
2 binding item comprises a tag specifying that no deformations are to be applied,

3 and wherein the deformation nodes allow the binding item having the tag to
4 pass without deformation.

1 28. The animation deformation pipeline of claim 24, further comprising at
2 least one masking node for modifying tags.

1 29. The animation deformation pipeline of claim 28, wherein the masking
2 node modifies a tag to specify that a binding item be excluded from deformation
3 by a particular deformation node.

1 30. The animation deformation pipeline of claim 1, wherein each node
2 comprises a graphics hardware component.

1 31. The animation deformation pipeline of claim 1, wherein:
2 the object comprises a plurality of surfaces;
3 the data stream comprises at least one data block for each surface of the
4 object;
5 and each deformation node applies a deformation by modifying at least
6 one data block associated with the object surface being de-
7 formed.

1 32. The animation deformation pipeline of claim 31, wherein each surface
2 is associated with a plurality of control vertices, and wherein each data block

3 comprises a binding item entry for each control vertex of the surface associated
4 with the data block.

1 33. The animation deformation pipeline of claim 1, wherein each defor-
2 mation node comprises a user-specifiable attribute for enabling and disabling the
3 node.

1 34. The animation deformation pipeline of claim 1, wherein each defor-
2 mation node comprises a user-specifiable attribute indicating a blending mode.

1 35. The animation deformation pipeline of claim 1, wherein each defor-
2 mation node comprises a user-specifiable attribute indicating a weighting factor.

1 36. A method for deforming a computer-generated object using a defor-
2 mation pipeline, comprising:
3 converting a geometric representation of an object into a data stream;
4 for each of a plurality of deformation nodes, receiving the data stream and
5 applying a deformation to the data stream; and
6 converting the deformed data stream into a geometric representation of a
7 deformed object.

1 37. The method of claim 36, wherein for at least a subset of the deforma-
2 tion nodes, applying a deformation comprises applying the deformation in re-
3 sponse to manipulation of a polygonal proxy model.

1 38. The method of claim 36, further comprising, for each of the deforma-
2 tion nodes, passing the data stream to a succeeding node.

1 39. The method of claim 36, wherein for at least a subset of the deforma-
2 tion nodes, applying a deformation comprises applying the deformation using a
3 sequential binding mode.

1 40. The method of claim 39, wherein for at least a subset of the deforma-
2 tion nodes, applying a deformation comprises applying the deformation to the
3 result of a previous deformation node.

1 41. The method of claim 39, further comprising, for each of the deforma-
2 tion nodes, receiving within the data stream a representation of a point, deform-
3 ing the point, and passing, to a succeeding node, a representation of the de-
4 formed point.

1 42. The method of claim 36, wherein for at least a subset of the deforma-
2 tion nodes, applying deformations comprises using a parallel binding mode.

1 43. The method of claim 42, wherein for at least a subset of the deforma-
2 tion nodes, applying a deformation comprises combining influences of at least
3 two polygonal proxy models.

1 44. The method of claim 42, wherein each deformation node receives,
2 within the data stream, a representation of a point, deforms the point, and
3 passes, to a succeeding node, a representation of the undeformed point.

1 45. The method of claim 42, further comprising, for each of the deforma-
2 tion nodes, receiving, within the data stream, a representation of a point, deform-
3 ing the point, and passing, to a succeeding node, a representation of the de-
4 formed point and a representation of the undeformed point.

1 46. The method of claim 36, wherein for at least a subset of the deforma-
2 tion nodes, applying a deformation comprises applying deformations using a
3 blend binding mode.

1 47. The method of claim 46, further comprising, for at least a subset of the
2 deformation nodes interpolating a current deformation with output of at least
3 one other deformation node.

1 48. The method of claim 36, wherein for at least a subset of the deforma-
2 tion nodes, applying a deformation comprises applying deformations using a hi-
3 erarchical binding mode.

1 49. The method of claim 48, wherein for at least a subset of the deforma-
2 tion nodes, applying a deformation comprises applying deformations to a local
3 origin point of an input binding site.

1 50. The method of claim 36, further comprising, for at least a subset of the
2 deformation nodes, receiving a user-specifiable weight parameter controlling the
3 relative amount of deformation applied by the node.

1 51. The method of claim 50, further comprising, for at least a subset of the
2 deformation nodes, generating output representing a weighted combination of
3 the input to the deformation node and the result of the deformation applied by
4 the node.

1 52. The method of claim 50, further comprising normalizing the weights
2 over the entire pipeline.

1 53. The method of claim 36, wherein, for at least a subset of the deforma-
2 tion nodes, applying a deformation node comprises:
3 determining a binding site for at least one control vertex of the object;

4 transforming the binding site;
5 propagating the transformation of the binding site to the control vertex of
6 the object, to establish a new location for the control vertex; and
7 deforming the object according to the new location of the control vertex.

1 54. The method of claim 53, wherein the binding sites are locations in a
2 subdivision surface.

1 55. The method of claim 53, wherein the binding sites are components of a
2 polygonal proxy model, and wherein propagating the transformation comprises
3 deforming a subdivision surface, wherein the subdivision surface passes smooth
4 deformations to the control vertices of the object.

1 56. The method of claim 36, further comprising, for each deformation
2 node, generating data stream output for another node, the data stream output
3 comprising a representation of the deformed object.

1 57. The method of claim 36, wherein the data stream comprises a plurality
2 of binding items to be deformed by deformation nodes.

1 58. The method of claim 57, wherein the binding items comprise tags
2 specifying binding modes.

1 59. The method of claim 58, wherein each deformation node has a binding
2 mode, and wherein, for each deformation node, applying a deformation com-
3 prises applying a deformation on binding items having a tag specifying a match-
4 ing binding mode.

1 60. The method of claim 36, wherein:
2 the object comprises a plurality of surfaces;
3 the data stream comprises at least one data block for each surface of the
4 object;
5 and wherein, for each deformation node, applying a deformation com-
6 prises modifying at least one data block associated with the ob-
7 ject surface being deformed.

1 61. The method of claim 60, wherein each surface is associated with a plu-
2 rality of control vertices, and wherein each data block comprises a binding item
3 entry for each control vertex of the surface associated with the data block.

1 62. The method of claim 36, further comprising, for each deformation
2 node, receiving a user-specifiable attribute for enabling and disabling the node.

1 63. The method of claim 36, further comprising, for each deformation
2 node, receiving a user-specifiable attribute indicating a blending mode.

1 64. The method of claim 36, further comprising, for each deformation
2 node, receiving a user-specifiable attribute indicating a weighting factor.

1 65. A computer program product for deforming a computer-generated
2 object using a deformation pipeline, comprising:

3 a computer-readable medium; and

4 computer program code, encoded on the medium, for:

5 converting a geometric representation of an object into a data

6 stream;

7 for each of a plurality of deformation nodes, receiving the data

8 stream and applying a deformation to the data stream;

9 and

10 converting the deformed data stream into a geometric representa-

11 tion of a deformed object.

1 66. The computer program product of claim 65, wherein for at least a sub-
2 set of the deformation nodes, the computer program code for applying a defor-
3 mation comprises computer program code for applying the deformation in re-
4 sponse to manipulation of a polygonal proxy model.

1 67. The computer program product of claim 65, further comprising com-
2 puter program code for, for each of the deformation nodes, passing the data
3 stream to a succeeding node.

1 68. The computer program product of claim 65, wherein for at least a sub-
2 set of the deformation nodes, the computer program code for applying a defor-
3 mation comprises computer program code for applying the deformation using a
4 sequential binding mode.

1 69. The computer program product of claim 68, wherein for at least a sub-
2 set of the deformation nodes, the computer program code for applying a defor-
3 mation comprises computer program code for applying the deformation to the
4 result of a previous deformation node.

1 70. The computer program product of claim 68, further comprising, for
2 each of the deformation nodes, computer program code for receiving within the
3 data stream a representation of a point, deforming the point, and passing, to a
4 succeeding node, a representation of the deformed point.

1 71. The computer program product of claim 65, wherein for at least a sub-
2 set of the deformation nodes, the computer program code for applying deforma-
3 tions uses a parallel binding mode.

1 72. The computer program product of claim 71, wherein for at least a sub-
2 set of the deformation nodes, the computer program code for applying a defor-
3 mation comprises computer program code for combining influences of at least
4 two polygonal proxy models.

1 73. The computer program product of claim 71, wherein each deforma-
2 tion node receives, within the data stream, a representation of a point, deforms
3 the point, and passes, to a succeeding node, a representation of the undeformed
4 point.

1 74. The computer program product of claim 71, further comprising, for
2 each of the deformation nodes, computer program code for receiving, within the
3 data stream, a representation of a point, deforming the point, and passing, to a
4 succeeding node, a representation of the deformed point and a representation of
5 the undeformed point.

1 75. The computer program product of claim 65, wherein for at least a sub-
2 set of the deformation nodes, the computer program code for applying a defor-
3 mation comprises computer program code for applying deformations using a
4 blend binding mode.

1 76. The computer program product of claim 75, further comprising com-
2 puter program code for, for at least a subset of the deformation nodes interpolat-
3 ing a current deformation with output of at least one other deformation node.

1 77. The computer program product of claim 65, wherein for at least a sub-
2 set of the deformation nodes, the computer program code for applying a defor-
3 mation comprises computer program code for applying deformations using a hi-
4 erarchical binding mode.

1 78. The computer program product of claim 77, wherein for at least a sub-
2 set of the deformation nodes, the computer program code for applying a defor-
3 mation comprises computer program code for applying deformations to a local
4 origin point of an input binding site.

1 79. The computer program product of claim 65, further comprising, for at
2 least a subset of the deformation nodes, computer program code for receiving a
3 user-specifiable weight parameter controlling the relative amount of deformation
4 applied by the node.

1 80. The computer program product of claim 79, further comprising, for at
2 least a subset of the deformation nodes, computer program code for generating

3 output representing a weighted combination of the input to the deformation
4 node and the result of the deformation applied by the node.

1 81. The computer program product of claim 79, further comprising com-
2 puter program code for normalizing the weights over the entire pipeline.

1 82. The computer program product of claim 65, wherein, for at least a
2 subset of the deformation nodes, the computer program code for applying a
3 deformation node comprises computer program code for:
4 determining a binding site for at least one control vertex of the object;
5 transforming the binding site;
6 propagating the transformation of the binding site to the control vertex of
7 the object, to establish a new location for the control vertex; and
8 deforming the object according to the new location of the control vertex.

1 83. The computer program product of claim 82, wherein the binding sites
2 are locations in a subdivision surface.

1 84. The computer program product of claim 82, wherein the binding sites
2 are components of a polygonal proxy model, and wherein the computer program
3 code for propagating the transformation comprises computer program code for
4 deforming a subdivision surface, wherein the subdivision surface passes smooth
5 deformations to the control vertices of the object.

1 85. The computer program product of claim 65, further comprising, for
2 each deformation node, computer program code for generating data stream out-
3 put for another node, the data stream output comprising a representation of the
4 deformed object.

1 86. The computer program product of claim 65, wherein the data stream
2 comprises a plurality of binding items to be deformed by deformation nodes.

1 87. The computer program product of claim 86, wherein the binding
2 items comprise tags specifying binding modes.

1 88. The computer program product of claim 87, wherein each deforma-
2 tion node has a binding mode, and wherein, for each deformation node, the
3 computer program code for applying a deformation comprises computer pro-
4 gram code for applying a deformation on binding items having a tag specifying a
5 matching binding mode.

1 89. The computer program product of claim 65, wherein:
2 the object comprises a plurality of surfaces;
3 the data stream comprises at least one data block for each surface of the
4 object;

5 and wherein, for each deformation node, the computer program code for
6 applying a deformation comprises computer program code for
7 modifying at least one data block associated with the object sur-
8 face being deformed.

1 90. The computer program product of claim 89, wherein each surface is
2 associated with a plurality of control vertices, and wherein each data block com-
3 prises a binding item entry for each control vertex of the surface associated with
4 the data block.

1 91. The computer program product of claim 65, further comprising, for
2 each deformation node, computer program code for receiving a user-specifiable
3 attribute for enabling and disabling the node.

1 92. The computer program product of claim 65, further comprising, for
2 each deformation node, computer program code for receiving a user-specifiable
3 attribute indicating a blending mode.

4 93. The computer program product of claim 65, further comprising, for
5 each deformation node, computer program code for receiving a user-specifiable
6 attribute indicating a weighting factor.